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A DISTRIBUTIONAL AND ECOLOGICAL STUDY OF MOUNT RAINIER, WASHINGTON¹

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Physiography

Mount Rainier is composed almost wholly of basaltic rock built up from the cinders, bombs, and liquid lava of its own eruptions, granite appearing in but few scattered places. An explosion which blew off the top of the mountain is supposed to have reduced its height some 2,000 feet, and to have left a capacious crater nearly three miles in diameter from north to south. Subsequently two small cinder cones filled this crater and, adding to their height, formed a low rounded dome which is the mountain's summit at present (Matthes, 1914, p. 7).

According to Matthes the total area of the glaciers of Mount Rainier is forty-five square miles, ". . . an expanse of ice far exceeding that of any other single peak in the United States." These glaciers, more than twenty-five in number, have had a profound effect on the topography of the mountain, grinding out deep channels on its sides, and leaving huge wedges of rock in relief between. The wedges, heading in sharp points near the summit, give place, as one descends, to grassy and flower-covered meadows. Lower

¹ During the summer field season of 1919 biological field work was carried forward in Mount Rainier National Park by the Bureau of Biological Survey of the U. S. Department of Agriculture, the State College of Washington, and the National Park Service of the U. S. Department of the Interior. Attention had been directed to Mount Rainier for several reasons. The biological survey of the State of Washington had progressed to a point where a study of one of the important mountains in the Cascade chain lying wholly west of the main summit was desirable; and Mount Rainier is the most massive as well as the highest of the four principal mountains (Baker, Glacier, Rainier, St. Helens) fulfilling this description. It was anticipated also that fewer modifications in natural conditions as a result of interference by man would be observable in the National Park than elsewhere; and it was thought that the results of the study would be of interest to a wider circle than would otherwise be the case.

The field party at different times included the following: J. B. Flett, Senior Park Ranger, National Park Service; Stanton Warburton, Jr., Tacoma, Washington; William L. Finley and family, Portland, Oregon; J. W. Hungate, State Normal School, Cheney, Washington; Professor William T. Shaw, State College of Washington; George G. Cantwell, Biological Survey, Puyallup, Washington; Stanley G. Jewett, Biological Survey, Portland, Oregon; and the writer, who was in general charge of the work.

A comprehensive account of the birds and mammals of Mount Rainier, to be published by the National Park Service, has been completed recently by Professor William T. Shaw and the writer. Free quotation has here been made from the introductory paragraphs of the larger work.

down appear deep, glacier-carved canyons and high, steep-sided ridges, all heavily forested. Flowing from the ends of the various glaciers are a number of rivers, mostly muddy white in color, which become swollen and turbulent in midday during the summer season from the melting of ice and snow.

The climate of Mount Rainier is of the warm humid type, partaking more of that of the coast strip of Washington than of the arid eastern portion of the State. A conspicuous feature is the heavy precipitation, the total measured snowfall at Paradise Inn during 1916-17 (789.5 inches) being apparently greater than for any Weather Bureau station in the United States for any entire season, with the single exception of Tamarack, California, in 1906-7 (Fisher, 1919, p. 328). The snowfall appears to be heavier in Indian Henrys Hunting Ground (on the southwest slope of the mountain) and lighter in Summerland (on the east slope) than in Paradise Valley, which is on the south slope. As might be expected, the extremely humid climate of the mountain, and the differences in precipitation on its slopes, exercise an important influence on the occurrence and distribution of its animals and plants.

Communities of Birds, Mammals, and Plants

LIFE ZONE, HABITAT, AND ASSOCIATION

Life Zones

"As a fundamental expression of progressive change in the amount of heat and water, zonation is the most important feature of vegetation," as one observer has said (Clements, 1905, p. 281). As used by the present writer, a *life zone* is an area inhabited by a more or less definite group of animals and plants limited in its distribution chiefly by temperature. It should be emphasized that classification of living forms by zones or habitats in the present state of knowledge is largely for convenience, and is often quite arbitrary.

Habitats and Associations

As already stated, moisture relations play an important rôle in relation to the occurrence and distribution of the animals and plants of Mount Rainier. A conception of the situation can be gained by using the *habitat* and *association*. The *habitat*, to adapt and modify somewhat a definition by Clements (1905, p. 292), is an area characterized by some efficient difference in one or more of the direct factors, humidity, water content, light, by virtue of which the fauna and flora are different from those surrounding them. As used by the present writer the term *association* is used for the group of plants and animals of a particular habitat.

A habitat may occupy the same area as that of a life zone; more often it occupies only a part of a zone, or transcends zonal boundaries. The principal plant and animal habitats of Mount Rainier can in the main be classified on a

moisture basis. A combination of the life zone, mapped on broad lines with temperature as the basic factor, and the habitat with its association, determined chiefly on water relations, should afford a more adequate picture of the distribution of plant and animal life on Mount Rainier than would either alone.

LIFE ZONES OF MOUNT RAINIER

Four life zones are represented on the mountain, the Transition, Canadian, Hudsonian, and Arctic-Alpine. The zones are somewhat obscured as a result of the powerful influence of humidity in western Washington, an influence to which Mount Rainier, lying 12 miles west of the main divide of the Cascade Mountains, is fully subject.

Transition Zone

The Transition Zone occupies the smallest area and is the least important of the zones of the Park. Although Transition elements occur occasionally up to 3,500 or even 4,000 feet at certain points on the west side of the mountain and were noted on the Carbon, Puyallup, Mowich, Nisqually, and other river systems, the Zone can be clearly recognized in the southeastern part of the Park only, where it is found in a limited area (four to six square miles) on Stevens Creek and the Muddy Fork of Cowlitz River below an altitude of 3,000 feet. In this region there occurred in the old Indian days repeated fires which laid waste a great area and profoundly modified the plant and animal population. This burning has evidently favored the upward advance of low zone elements.

Among the plants here indicating Transition Zone, but not necessarily confined to it, are the grand or white fir *Abies grandis*, salal *Gaultheria shallon*, Oregon grape *Berberis nervosa*, western bracken *Pteridium aquilinum pubescens*, red alder *Alnus oregona*, large-leaf maple *Acer macrophyllum*, vine maple *Acer circinatum*, western cottonwood *Populus trichocarpa*, early willow *Salix scouleriana*, western dogwood *Cornus occidentalis*, ocean spray *Sercotheca discolor*, devil's club *Echinopanax horridum*, salmon berry *Rubus spectabilis*, and fetid currant *Ribes bracteosum*. Birds of the Transition include the² California quail *Lophortyx californica californica*, Oregon ruffed grouse *Bonasa umbellus sabini*, northern spotted owl *Strix occidentalis caurina*, Lewis woodpecker *Asyndesmus lewisi*, nighthawk *Chordeiles virginianus* ssp., black-headed grosbeak *Zamelodia melanocephala*, yellow warbler *Dendroica aestiva* ssp., western warbling vireo *Vireosylva gilva swainsoni*, Parkman wren *Troglodytes aedon parkmani*, Seattle wren *Thryomanes bewicki calophonius*, and Oregon chickadee *Penthestes atricapillus occidentalis*. Mam-

² Permanent residents or summer visitants among the birds, when referred to particular zones or habitats, are assumed to breed therein. The few migrant birds listed are most commonly observed in the particular zone or habitat to which they are referred.

mals include the wandering shrew *Sorex vagrans vagrans*, Bendire water shrew *Neosorex bendirii bendirii*, raccoon *Procyon lotor pacifica*, mink *Mustela vison energumenos*, little spotted skunk *Spilogale phenax olympica*, Oregon meadow mouse *Microtus oregoni oregoni*, Olympic meadow mouse *Microtus mordax macrurus*, and the muskrat *Fiber zibethicus osoyoosensis*.

Canadian Zone

In this Zone is the heavily timbered area from the Park boundaries (except in the southeastern part of the Park) to 4,500–5,000 feet. This, then, is the area of huge trees of impressive diameter and height, and of mossy forest floor, usually clear of thick underbrush. Progress away from trails is laborious, for creeks and springs, uneven topography, and many huge logs make it difficult to maintain a footing. As a result of the dominating influence of the climax forest of western hemlock *Tsuga heterophylla*, Douglas fir *Pseudotsuga mucronata*, and giant cedar *Thuja plicata*, the growth of all but the most shade tolerant plants is prevented, and consequently the amount of food for birds and mammals is much reduced.

The Zone occupies an area of varying width all around the mountain. The deep-wooded canyons, and ridges between as well, are commonly referable to it, while the amphitheater-like parks on the headwaters of the principal streams belong to the Hudsonian Zone next above.

Plants commonly occurring in the Canadian Zone, in addition to the three trees just mentioned, are as follows: lovely fir *Abies amabilis*, noble fir *Abies nobilis*, lodgepole pine *Pinus contorta*, western white pine *Pinus monticola*, western yew *Taxus brevifolia*, bunchberry or Canada dogwood *Cornus canadensis*, *Menziesia ferruginea*, mountain ash *Pyrus sitchensis*, *Pachistima myrsinites*, forest anemone *Anemone deltoidea*, wild bleeding heart *Capnoides scouleri*, alpine beauty *Clintonia uniflora*, Mertens coral root *Corallorhiza mertensiana*, oak fern *Phegopteris dryopteris*, Mertens saxifrage *Saxifraga mertensiana*, and false Solomon's seal *Vagnera sessilifolia*.

The birds include the Harris woodpecker *Dryobates villosus harrisi*, Gairdner woodpecker *Dryobates pubescens gairdneri*, northern red-breasted sapsucker *Sphyrapicus ruber notkensis*, pileated woodpecker *Phloeotomus pileatus abieticola*, western flycatcher *Empidonax difficilis difficilis*, Steller jay *Cyanocitta stelleri stelleri*, western tanager *Piranga ludoviciana*, chestnut-backed chickadee *Parus rufescens rufescens*, western golden-crowned kinglet *Regulus satrapa olivaceus*, russet-backed thrush *Hylocichla ustulata ustulata*, and western bluebird *Sialia mexicana occidentalis*. Mammals occurring in this Zone are the Trowbridge shrew *Sorex trowbridgii*, brown bat *Eptesicus fuscus fuscus*, bobcat *Lynx fasciatus* ssp., Cooper chipmunk *Eutamias townsendi cooperi*, beaver *Castor canadensis pacificus*, and snowshoe rabbit *Lepus washingtonii washingtonii*.

It is difficult to make a distinction between Canadian and Transition Zones

on Mount Rainier because of the uniformity of the Douglas fir-western hemlock-giant cedar forest, which dominates the flora (excepting upper Canadian) in both. The species of birds and mammals listed above do not ordinarily occur above Canadian, though they are all found also in Transition. There are no birds or mammals characteristic exclusively of the Canadian Zone on the mountain.

Hudsonian Zone

At an altitude of approximately 4,500 feet the aspect of the forest changes. The Douglas fir has dropped out somewhat lower down, the lovely fir has become abundant, and now the western hemlock disappears. The trees are reduced in size, and the alpine fir and mountain hemlock, with the lovely fir, dominate the forest. One is now at the lower border of the Hudsonian Zone, which, on the average, embraces the area between 4,500 and 6,500 feet, including the narrow upper portion of the dense woods, as well as the meadow country between the forest and the limit of trees. This area constitutes a belt of varying width, being most extensive in the high country northeast of Mount Rainier, where it includes Grand Park and the Sourdough Mountain district.

This and the next are zones of wonderful scenery; and the Hudsonian Zone, above the narrow forested area, with its happy combination of open grassy park and subalpine flower garden on the one hand, and pinnacle and glacier on the other, is without doubt the most attractive zone on the mountain (see Flett, 1916). The shade of the deep Canadian forest is gone. Groups of handsome spire-like alpine firs and mountain hemlocks are set about the meadow borders or interspersed over the green expanses, always affording plenty of light and moisture to the grass and flowers. There is an abundance of food for birds and mammals, which are more conspicuous and probably more numerous in this Zone than in any other in the Park.

Plants occurring principally in this Zone are mountain hemlock *Tsuga mertensiana*, alpine fir *Abies lasiocarpa*, white-bark pine *Pinus albicaulis*, Alaska cedar *Chamaecyparis nootkatensis*, white heather *Cassiope mertensiana*, red heather *Phyllodoce empetriformis*, Jeffrey shooting star *Dodecatheon jeffreyi*, smooth larkspur *Delphinium glaucum*, avalanche lily *Erythronium montanum*, yellow deer tongue *Erythronium parviflorum*, delicious huckleberry *Vaccinium deliciosum*, small red huckleberry *Vaccinium scoparium*, mountain gentian *Gentiana calycosa*, lungwort *Mertensia laevigata*, ovate salal *Gaultheria ovatifolia*, Nuttall gilia *Gilia nuttallii*, Sitka valerian *Valeriana sitchensis*, green hellebore *Veratrum viride*, squaw grass *Xerophyllum tenax*, Siberian juniper *Juniperus sibirica*, jacob's ladder *Polemonium humile*, mountain dock *Polygonum bistortoides*, subalpine lupine *Lupinus subalpinus*, western anemone or monkey whiskers *Pulsatilla occidentalis*, Suksdorf buttercup *Ranunculus suksdorfii*, and Cusick speedwell *Veronica cusickii*. Among the

birds of the Zone are the golden eagle *Aquila chrysaetos*, saw-whet owl *Cryptoglaux acadica acadica*, Clark nutcracker *Nucifraga columbiana*, Cassin purple finch *Carpodacus cassinii*, western chipping sparrow *Spizella passerina arizonae*, lutescent warbler *Vermivora celata lutescens*, mountain chickadee *Penthestes gambeli gambeli*, Townsend solitaire *Myadestes townsendi*, hermit thrush *Hylocichla guttata sequoiensis*, and mountain bluebird *Sialia currucoides*. The mammals include the red fox *Vulpes cascadenis*, Washington weasel *Mustela washingtoni*, Canada lynx *Lynx canadensis*, mountain lemming mouse *Phenacomys orophilus olympicus*, Rainier meadow mouse *Microtus oregoni cantwelli*, large-footed meadow mouse *Microtus richardsoni arvicoloides*, Rainier pocket gopher *Thomomys douglasii shawi*, Cascade hoary marmot *Marmota caligata cascadenis*, little chipmunk *Eutamias amoenus caurinus*, mantled ground squirrel *Callospermophilus lateralis saturatus*, and cony *Ochotona fenisex brunnescens*.

Arctic-Alpine Zone

At or close to the 6,500-foot contour the Arctic-Alpine Zone is entered. Here belong the conspicuous snow- and ice-covered upper slopes of the mountain, comprising an area of approximately eighty square miles. With its wilderness of glacier, snow-slope, rocky cleaver, beetling cliff, and massive wedge, the scenery of the Arctic-Alpine is of a highly attractive character.

The heaviest snowfall takes place at moderate elevations, most of the glaciers originating in amphitheaters at about 10,000 feet elevation (Matthes, 1914, p. 21).

The Arctic-Alpine is the particular dwelling place of the Sandwort *Arenaria capillaris nardifolia*, two kinds of Indian paint brushes *Castilleja oreopola* and *C. rupicola*, *Draba aureola*, crow berry *Empetrum nigrum*, alpine buckwheat *Eriogonum pyrolaeifolium coryphaeum*, *Phacelia sericea*, golden aster *Erigeron aureus*, *Gilia debilis*, *Hulsea nana*, mountain aster *Oreostemma alpigena*, pigeon-billed lousewort *Pedicularis ornithorhyncha*, *Pentstemon menziesii*, yellow heather *Phyllodoce glanduliflora*, Lyall lupine *Lupinus lyallii*, snowy willow *Salix nivalis*, Tolmie saxifrage *Saxifraga tolmiei*, *Smeilowskia ovalis*, *Spraguea multiceps*, and *Polemonium viscosum*. Four birds, the pallid horned lark *Otocoris alpestris arctica*, rosy finch *Leucosticte tephrocotis littoralis*, pipit *Anthus rubescens*, and ptarmigan *Lagopus leucurus rainierensis*, and one mammal, the mountain goat *Oreamnos montanus*, also occur in this Zone.

In winter the rocky slopes above timberline, where in summer such animals as the ptarmigan and mountain goat find food, are deeply covered with snow except where the wind exposes the rocky ridges. An alternate freezing and thawing often coats all exposed surfaces with glare ice, which renders food unobtainable and life for birds or mammals of this sort impossible.

THE HABITATS OF MOUNT RAINIER

The following habitats are characterized by extreme moisture: stream, stream-border, lake, lake-shore, and swamp. Those having moderate moisture are meadow, forest (including the several strata of vegetation due perhaps principally to light, with associated animal life), and burn. Habitats of deficient moisture or of a rocky type include alpine ridge, pumice slope, and rock-slide. The glacier habitat probably furnishes little available water so is tentatively placed here also.

As noted in the paragraph on Life Zones, page 215, the classification of living forms by zones or habitats, in the present state of knowledge, is largely for convenience, and often quite arbitrary. It will be impossible to give a fully satisfactory account of the distribution and relationships of the plants and animals of Mount Rainier until a thorough ecological survey is accomplished.

Habitats Characterized by Extreme Moisture

Lake, lake-shore, stream, stream-border, swamp.—There are few lakes of any size in the Park, the largest being Crater or Mowich Lake northwest of the mountain. Practically all the lakes are glacial tarns, most of them located at altitudes exceeding 4,000 feet. Ordinarily they lie at so great an altitude in the glacier-hewn amphitheaters that their shores are rocky and devoid of conspicuous vegetation, although scenically they are wonderfully attractive.

The turbulent streams of the mountain, fed by glaciers, and becoming much swollen in midday and afternoon when the sun shines, are a conspicuous feature of the Park. Taking origin from the snouts of the glaciers or from springs or swamps on the meadows, the streams radiate from the mountain in all directions, and give rise to not a few waterfalls and cascades of extraordinary beauty.

True swamps are of limited extent and fade imperceptibly into stream-borders on the one hand and meadows on the other. Restricted areas about Longmire Springs, Reflection Lakes, and Mountain Meadows may be classified here. There are also swampy tracts at intervals along some of the streams of the Park, as Tahoma Creek, Ohanapecosh River, and White River.

Willows of several species, *Salix commutata*, *S. barclayi*, and *S. lasiandra*, grow on the shores of some of the lakes at more moderate altitudes, as do also *Kalmia glauca microphylla* and the common horsetail *Equisetum arvense*. Occurring characteristically in the immediate vicinity of streams are the alpine monkey flower *Mimulus alpinus*, Lewis monkey flower *Mimulus lewisii*, yellow fireweed *Epilobium luteum*, *Cardamine kamtschatica*, and silky willow *Salix sitchensis*. Swamp plants include the cat-tail *Typha latifolia*, skunk cabbage *Lysichiton camtschaticense*, swamp star flower *Trientalis arctica*, *Hypericum anagalloides*, and the Jeffrey shooting star *Dodecatheon jeffreyi*. Among the birds of these moist habitats are the red-breasted merganser

Mergus serrator, harlequin duck *Histrionicus histrionicus*, pintail *Dafila acuta*, great blue heron *Ardea herodias fannini*, semipalmated sandpiper *Ereunetes pusillus*, spotted sandpiper *Actitis macularius*, belted kingfisher *Ceryle alcyon*, water ouzel *Cinclus mexicanus unicolor*, and Lincoln sparrow *Melospiza lincolni*. Mammals include the navigator water shrew *Neosorex navigator navigator*, Bendire water shrew *Neosorex bendirii bendirii*, Gibbs shrew mole *Neurotrichus gibbsii gibbsii*, raccoon *Procyon lotor pacifica*, mink *Mustela vison energumenos*, otter *Lutra canadensis pacifica*, large-footed meadow mouse *Microtus richardsoni arvicoloides*, muskrat *Fiber zibethicus osoyoosensis*, and beaver *Castor canadensis pacificus*.

Habitats Characterized by Moderate Moisture

Meadow.—The Hudsonian Zone meadows of Mount Rainier are second only to its glaciers in interest, for they are among the most famous natural flower gardens in the world. Meadows of limited extent occur in the Canadian and Arctic-Alpine Zones also. The Hudsonian Zone meadows are extensive and include a number of well-known parks just below timberline, as Paradise Park, Grand Park, Spray Park, Sunset Park, and St. Andrew's Park.

The principal Hudsonian meadow plants have been already mentioned (see pages 218–219). Canadian meadow forms include the rosy spiraea *Spiraea densiflora*, *Trautvetteria grandis*, lousewort *Pedicularis bracteosa*, and *Limnorchis leucostachys*. The meadows of the Arctic-Alpine, which grade by imperceptible degrees into the Arctic-Alpine ridges of deficient moisture (see page 224), exhibit *Smelowskia ovalis*, Lyall lupine *Lupinus lyalli*, *Saxifraga caespitosa*, snowy willow *Salix nivalis*, *Arenaria verna*, crowberry *Empetrum nigrum*, golden aster *Erigeron aureus*, *Solidago algida*, lousewort *Pedicularis contorta*, alpine buckwheat *Eriogonum pyrolaefolium coryphaeum*, and *Ago-seris alpestris*. Among meadow birds are the rufous hummingbird *Selasphorus rufus*, pallid horned lark *Otocoris alpestris arcticola*, western meadow lark *Sterna neglecta* ssp., Brewer blackbird *Euphagus cyanocephalus*, Savanna sparrow *Passerculus sandwichensis alaudinus*, and western robin *Planesticus migratorius propinquus*. Meadow mammals include the coyote *Canis latrans lestes*, mountain lemming mouse *Phenacomys orophilus olympicus*, Oregon meadow mouse *Microtus oregoni oregoni*, Rainier meadow mouse *M. oregoni cantwelli*, Rocky Mountain meadow mouse *M. mordax mordax*, Olympic meadow mouse *M. m. macrurus*, large-footed meadow mouse *M. richardsoni arvicoloides*, Rainier pocket gopher *Thomomys douglasii shawi*, and jumping mouse *Zapus trinotatus trinotatus*.

Forest.—This habitat is one of the most conspicuous on the mountain. The forest is of a dense and somber character. "The trees, pushing upward for light, are very tall and free from limbs for more than half their height. Their tops form a continuous cover which the sunshine rarely penetrates, and

on which the light snows of early winter fall and melt, without reaching the ground. Even in midsummer the light is soft and shaded, and the air cool and humid" (Allen, 1916, p. 1). Exclusive of burns, the heavily forested tract embraces the area between the Park boundaries and 5,000 feet. The principal plants are, of course, trees, including the Douglas fir *Pseudotsuga mucronata*, western hemlock *Tsuga heterophylla*, lovely fir *Abies amabilis*, noble fir *Abies nobilis*, and giant cedar *Thuja plicata*. The western white pine *Pinus monticola* occurs at intervals through the forest, and at higher levels there is a considerable quantity of Alaska cedar *Chamaecyparis nootkatensis*, as well as some mountain hemlock *Tsuga mertensiana*. On the northeast side of the mountain the Engelmann spruce *Picea engelmanni* occurs commonly in this habitat. The lodgepole pine *Pinus contorta* is occasionally encountered, occurring principally in the White River region.

In a few places the upper boundary of the forest habitat coincides with that of the Canadian Zone, but normally the deep, shady wood extends into the lower Hudsonian Zone for about 500 feet of vertical altitude.

The forest habitat possesses height as well as breadth, and can be subdivided vertically into three main strata or layers, a ground stratum (including the forest floor), an intermediate stratum, and an uppermost stratum.

The forest floor is carpeted with mosses of two principal species, *Hypnum robustum* and *H. splendens*. Growing on this forest floor appear shade-tolerant species of plants, ranging from a few inches to several feet in height, able to live in the depths of the forest. Here are the bunch berry *Cornus canadensis*, alpine beauty *Clintonia uniflora*, bird's-foot bramble *Rubus pedatus*, vanilla leaf *Achlys triphylla*, forest anemone *Anemone deltoidea*, huckleberries *Vaccinium parviflorum*, etc., vine maple *Acer circinatum*, devil's club *Echinopanax horridum*, false Solomon's seal *Vagnera sessilifolia*, and thimbleberry *Rubus parviflorus*. In this ground stratum live the Oregon ruffed grouse *Bonasa umbellus sabinii* and the western winter wren *Nannus hiemalis pacificus*; and the hermit thrush *Hylocichla guttata sequoiensis* and russet-backed thrush *Hylocichla ustulata ustulata* spend most of their time here. Almost all the forest mammals except those which live principally in trees, like the flying squirrel, or in the air, like the bats, are found in this ground stratum. The woodrat *Neotoma cinerea occidentalis*, red-backed mouse *Eutamias gapperi saturatus*, Cooper chipmunk *Eutamias townsendi cooperi*, and Washington varying hare *Lepus washingtonii washingtonii* are numbered among these ground dwellers. Many other mammals are regularly found on the forest floor, including the dusky shrew *Sorex obscurus setosus*, black bear *Ursus americanus*, marten *Martes caurina caurina*, two kinds of weasels *Mustela washingtoni* and *M. streatori*, bobcat *Lynx fasciatus* ssp., white-footed mouse *Peromyscus maniculatus oreas*, and Columbian black-tailed deer *Odocoileus columbianus*.

As the intermediate stratum is entered, the number of plants and mammals

undergoes a marked decrease, while the number of birds increases. Practically the only conspicuous plants able to live in the upper strata are the lichens, chiefly *Sticta pulmonaria* and several species of *Usnea*. The Douglas squirrel *Citellus douglasii douglasii* and flying squirrel *Glaucomys sabrinus fuliginosus* are the principal mammalian inhabitants. These are bona fide residents of the intermediate stratum, though they are active on the ground, too. Many other mammals occasionally or often climb trees, for example the black bear, fisher *Martes pennanti pacifica*, marten, bobcat, cougar *Felis oregonensis oregonensis*, and Cooper chipmunk. Birds of the intermediate stratum include the band-tailed pigeon *Columba fasciata*, sharp-shinned hawk *Accipiter velox*, western goshawk *Astur atricapillus striatulus*, northern spotted owl *Strix occidentalis caurina*, saw-whet owl *Cryptoglaux acadica acadica*, screech owl *Otus asio* ssp., horned owl *Bubo virginianus* ssp., Harris woodpecker *Dryobates villosus harrisi*, Sierra hairy woodpecker *D. v. orius*, Gairdner woodpecker *Dryobates pubescens gairdneri*, Alaska three-toed woodpecker *Picoides americanus fasciatus*, northern red-breasted sapsucker *Sphyrapicus ruber notkensis*, pileated woodpecker *Phloeotomus pileatus abieticola*, tawny creeper *Certhia familiaris occidentalis*, western flycatcher *Empidonax difficilis*, Steller jay *Cyanocitta stelleri stelleri*, gray jay *Perisoreus obscurus griseus*, western evening grosbeak *Hesperiphona vespertina montana*, western tanager *Piranga ludoviciana*, slender-billed nuthatch *Sitta carolinensis aculeata*, red-breasted nuthatch *Sitta canadensis*, and mountain chickadee *Penthestes gambeli gambeli*. There are, of course, no hard and fast lines bounding any of these strata, and birds may and often do range freely into contiguous divisions. The American crossbill *Loxia curvirostra minor* and white-winged crossbill *L. leucoptera*, and the Townsend warbler *Dendroica townsendi* are perhaps more often found in the uppermost than in the intermediate stratum. The western golden-crowned kinglet *Regulus satrapa olivaceus* and chestnut-backed chickadee *Penthestes rufescens rufescens* are found in both intermediate and uppermost strata. With the possible exception of certain bats, no mammals occur exclusively in the uppermost stratum, though the Douglas squirrel and flying squirrel doubtless range into it quite freely.

Although deciduous trees, such as alders, cottonwoods, etc., are scarce within the Park, one group of birds, including the downy woodpecker, western warbling vireo, yellow warbler, and Oregon chickadee, prefers the deciduous forest habitat.

Burn.—Before the regulations governing the Park went into effect severe fires swept parts of the subalpine forest. There have resulted tracts of standing dead stubs or "ghost trees" with much fallen timber and brush between. A large area on the Muddy Fork of the Cowlitz River and on Stevens Creek has also been repeatedly burned (see page 216). The alpine burns recover very slowly, there being little apparent change within the last

thirty years (Allen, 1916, p. 5). At low elevations the forest recovers more rapidly. The importance of maintaining adequate fire protection is obvious.

Destruction of the climax forest throws back the vegetation into an earlier stage of development in which, disregarding the minor stages, appear various species of brush and herbs as fireweed *Epilobium angustifolium*, western bracken *Pteridium aquilinum pubescens*, blackberry *Rubus macro-petalus*, thimbleberry *Rubus parviflorus*, running pine *Lycopodium clavatum*, huckleberries *Vaccinium* sp., subalpine lupine *Lupinus subalpinus*, and squaw grass *Xerophyllum tenax*. Food of certain kinds is more abundant here than in the forest, and we find, among birds of the burn, the Oregon ruffed grouse *Bonasa umbellus sabini*, sparrow hawk *Falco sparverius phalaena*, nighthawk *Chordeiles virginianus* ssp., Lewis woodpecker *Asyndesmus lewisi*, Gambel sparrow *Zonotrichia leucophrys gambeli*, golden-crowned sparrow *Zonotrichia coronata*, Townsend solitaire *Myadestes townsendi*, western robin *Planesticus migratorius propinquus*, mountain bluebird *Sialia currucoides*, and western bluebird *Sialia mexicana occidentalis*; and among the mammals the black bear *Ursus americanus*, red fox *Vulpes cascadenis*, various meadow mice *Microtus* sp., mountain beaver *Aplodontia rufa rainieri*, jumping mouse *Zapus trinotatus trinotatus*, two kinds of chipmunks *Eutamias townsendi cooperi* and *E. amoenus caurinus*, and the Columbian black-tailed deer *Odocoileus columbianus*. Bears, deer, and chipmunks are often particularly numerous.

Brush is, of course, a characteristic of burns, often occurring also on meadow borders and along stream courses. In addition to certain ones of the birds listed above, there are others which are characteristically brush-inhabiting, such as the Oregon towhee *Pipilo maculatus oregonus*, rusty song sparrow *Melospiza melodia morphna*, Lincoln sparrow *Melospiza lincolni*, fox sparrows *Passerella iliaca* ssp., lutescent warbler *Vermivora celata lutescens*, Tolmie warbler *Oporornis tolmiei*, and the golden pileolated warbler *Wilsonia pusilla chryseola*.

Habitats Characterized by Deficient Moisture or of a Rocky Type

Alpine Ridge and Pumice Slope.—Above timberline in the intervals between glaciers and snowfields appear rocky ridges, the so-called cleavers, and more or less extensive pumice fields. With increase in altitude both flora and fauna quite naturally become less abundant, until finally, a little above 10,000 feet on Mount Rainier, practically all life ceases.³ On the pumice fields and rocky ridges appear mountain phlox *Phlox diffusa*, mountain sorrel *Oxyria digyna*, Lyall lupine *Lupinus lyallii*, *Spraguea multiceps*, alpine buckwheat *Eriogonum pyrolaefolium coryphaeum*, *Hulsea nana*, *Polemonium elegans*,

³ At least two mammals, the white-footed mouse, *Peromyscus maniculatus oreas*, and the little chipmunk, *Eutamias amoenus caurinus*, have been found near the summit of the mountain, altitude well over 14,000 feet. (See Taylor, 1920, p. 93.)

golden aster *Erigeron aureus*, mountain aster *Oreostemma alpigena*, *Polygonum newberryi*, *Poa suksdorfii*, *Draba aureola*, and *Smelowskia ovalis*. Birds include the Rainier white-tailed ptarmigan *Lagopus leucurus rainierensis*, golden eagle *Aquila chrysaetos*, rosy finch *Leucosticte tephrocotis littoralis*, and pipit *Anthus rubescens*. One mammal, the mountain goat *Oreamnos montanus*, makes its home here. Several others range into the habitat, among them the red fox *Vulpes cascadenis*, Canada lynx *Lynx canadensis*, timber wolf *Canis gigas*, coyote *Canis latrans lestes*, black bear *Ursus americanus*, white-footed mouse *Peromyscus maniculatus oreas*, large-footed meadow mouse *Microtus richardsoni arvicoloides*, Cascade hoary marmot *Marmota caligata cascadenis*, and little chipmunk *Eutamias amoenus caurinus*.

Rock-slide.—Stupendous amphitheaters formed principally by the tearing away of frost-split fragments of rock by glaciers are a characteristic topographic feature on all sides of the mountain. Rock slides or taluses are the inevitable and necessary consequence of weathering in this region, and are conspicuous in the Hudsonian Zone between altitudes of 4,500 and 6,500 feet.

Certain plants and animals have become well adapted to life in the rock-slides, which furnish them with home and shelter. Among plants, *Phegopteris alpestris*, vine maple *Acer circinatum*, and mountain ash *Pyrus occidentalis* are often found on the rock-slides. One mammal, the cony *Ochotona fenisex brunnescens*, is found almost exclusively in this habitat, though several others are frequently observed in it, these including the marten *Martes caurina caurina*, Washington weasel *Mustela washingtoni*, Streater weasel *M. streatori*, white-footed mouse *Peromyscus maniculatus oreas*, western bushy-tailed woodrat *Neotoma cinerea occidentalis*, little chipmunk *Eutamias amoenus caurinus*, mantled ground squirrel *Callospermophilus lateralis saturatus*, and Cascade hoary marmot *Marmota caligata cascadenis*. The Rainier white-tailed ptarmigan *Lagopus leucurus rainierensis* spends much time on the rock-slides, although it is more characteristic of alpine ridge, glacier, and pumice slope.

Glacier.—It is difficult to decide just where to place the "Glacier" habitat, for though it is characterized by extreme moisture, this moisture is mostly unavailable, and the habitat is actually closely related, so far, at least, as its birds and mammals are concerned, to alpine ridge and pumice slope.

As is well known, several species of insects, chiefly members of the low order *Thysanura*, are found on the surface of the glaciers; worms of the genus *Mesenchytraeus* occur plentifully on the lower parts of the glaciers; and probably numerous microscopic plants are also to be found. The bacterium *Protococcus nivalis*, colonies of which make the patches of red snow, is conspicuous because of its color (Matthes, 1914, pp. 16-17). The pea fern *Cryptogramma acrostichoides*, stone crop *Sedum divergens*, mountain alder *Alnus sinuata*, and *Collomia debilis* grow on the moraines in intimate relation to glaciers.

No birds or mammals are exclusive inhabitants of the glacier habitat, but a number of them are occasionally found on the glaciers. These include the Rainier white-tailed ptarmigan *Lagopus leucurus rainierensis* and rosy finch *Leucosticte tephrocotis littoralis* among birds, and two kinds of weasels *Mustela washingtoni* and *M. streatori*, the marten *Martes caurina caurina*, timber wolf *Canis gigas*, coyote *Canis latrans lestes*, black bear *Ursus americanus*, mountain lemming mouse *Phenacomys orophilus olympicus*, and mountain goat *Oreamnos montanus* among mammals.

Special Considerations

THE WHITE RIVER AREA

White River, rising in Glacier Basin northeast of the mountain, trends in a general northeasterly direction until it leaves the Park at its extreme northeast corner. The broad basin drained by this river possesses several noteworthy peculiarities. The upper boundary of the Canadian Zone, in this region, is 500 feet higher than elsewhere about the mountain; the area is noticeably more arid than other parts of the Park; and there are differences both in fauna and flora. The trees on the northeast side of the mountain do not attain the huge dimensions of those of the west and southwest. *Picea engelmanni* and *Ceanothus velutinus* appear for the first time, and *Pinus contorta* and *P. albicaulis* become far more abundant than elsewhere. Among mammals *Callospermophilus lateralis saturatus*, *Marmota caligata cascadenis*, and apparently *Eutamias amoenus caurinus* are more numerous. *Thomomys douglasii shawi* occurs on the east side of the Park only, from Cowlitz Ridge to Grand Park. Among birds *Nucifraga columbiana* is more common in this section than elsewhere, and *Spizella passerina arizonae* was here recorded for the first time.

Areas of obvious aridity, as Yakima and Grand Parks, are conspicuous on the northeast side of the mountain. One day during the first week in August, 1919, as the writer stood on Panhandle Gap (altitude 7,300 feet) with a great area of Mount Rainier Park in full view to the north, east, and south, a heavy fog was observed obscuring the Longmire country, Stevens Canyon, and, in fact, all the region to the south and west; while Summerland, White River, and the country to the north and east were free from fog or were shadowed by scattered cloud masses only. Subsequent evidence indicated that there is a real and probably not inconsiderable climatic difference between the areas which on that occasion were fog-covered and those where the sun was shining.

The relative aridity of the northeast side of Mount Rainier can apparently be accounted for by the direction of the winds in the region. According to J. B. Flett, Senior Park Ranger and Cooperative Weather Observer, at Longmire, Mount Rainier, Washington, the prevailing direction of the wind is

southwest, nine tenths of all the storms coming from that direction. While weather records from the east and northeast sides of Mount Rainier are lacking, we can safely conclude that there is far less precipitation there than on the west and southwest slopes. The order of difference which might be expected may perhaps be fairly assumed from the consideration of a near-by region. Clearwater, Jefferson County, Washington, lying southwest of the Olympic Mountains, received, between the years 1898 and 1907, inclusive, a mean annual precipitation of 127.90 inches; while Seattle, lying east of the Olympics, received, between the years 1892 and 1913, inclusive, a mean annual precipitation of but 34.36 inches (Salisbury, 1915, p. 5). There is then, little doubt that considerably more snow falls on the southwest slopes of Mount Rainier than on the northeast. If this is the case, one would expect the various zonal boundaries to be somewhat higher on the northeast than on the southwest, for the snow would disappear at an earlier date and the warm growing season would be prolonged.

The direction of the prevailing winds probably accounts also for the presence in the northeast part of the Rainier Park of a greater amount of volcanic ash soil than elsewhere about the mountain. This soil is of an extremely porous character and does not hold moisture, consequently wherever it appears the country is likely to have a dry aspect. Whatever may be the cause, it is a fact that Yakima Park, the Sourdough Mountain district, and the Grand Park region, all of which lie northeast of the mountain, are the most arid-appearing portions of the entire Rainier area.

TIMBERLINE ON MOUNT RAINIER

The extreme limit of tree growth on Mount Rainier is 7,600 feet above sea level (Allen, 1916, p. 3), but trees seldom reach this altitude. As Piper has noted (1906, p. 62) timberline extends to a much higher altitude on the ridges than in the draws between, there being more than 2,000 feet difference on Mount Rainier. The average altitude of timberline on the mountain is 6,500 feet.

To one accustomed to Rocky Mountain or Sierran conditions this will seem surprisingly low, especially in view of the fact that Mount Rainier has a warm humid climate. Even on the east slopes of the Cascade Mountains of Washington, where the climatic extremes are considerably more severe, timberline averages about a thousand feet higher.

In their recent paper on the plants and animals of Mount Marcy, New York, Adams, Burns, Hankinson, Moore, and Taylor suggest that effective temperatures, wind, and depth of snow are the most important factors causing timberline on mountains (1920, p. 286). While it is altogether likely that these factors, and possibly others, have an effect on Mount Rainier, it is not improbable that the excessive snowfall on the mountain is the most important of them all (see Allen, 1916, p. 3).

The winter storms frequently begin as early as September, and the steadily accumulating snow lasts through until the following July. Timberline trees are subjected to a stress and strain of the severest character. The congealing of the moist snow on their branches frequently weights them down so that their branches are actually broken off, and sometimes the entire tree is laid low. The comparatively moderate winter temperature probably has an effect here, the alternate freezing and thawing doubtless being more difficult to withstand than is a considerably lower temperature.

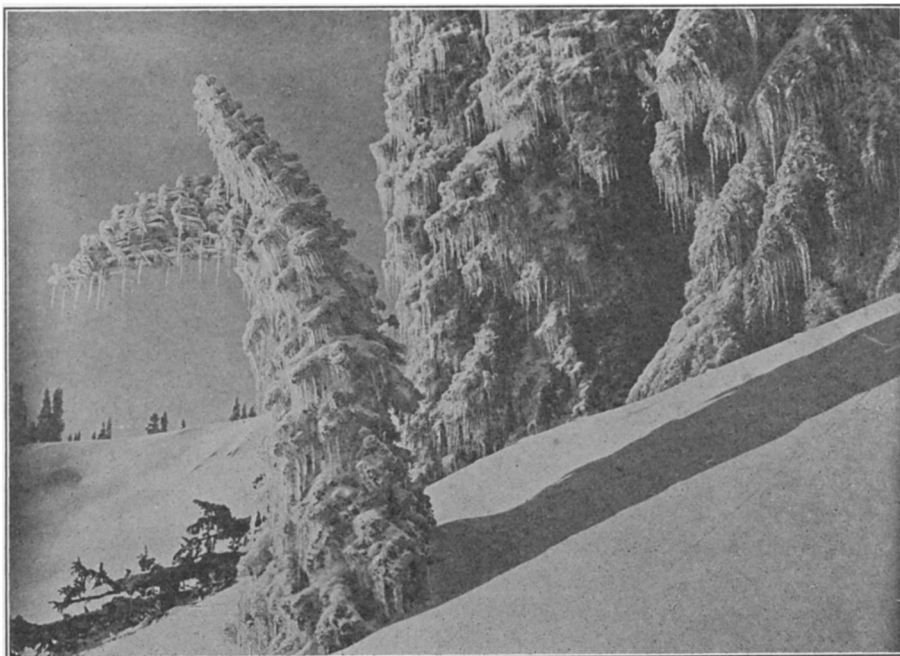


FIG. 1. Trees in winter at 5,800 feet altitude near timber line on Mount Rainier. One tree (on left) has been broken down. Photograph taken January 20, 1920, by J. B. Flett.

Although greater extremes of temperature are undoubtedly registered on the east slopes of the Cascades in Washington, the snowfall is not nearly so heavy, and the trees run up the mountain sides for a thousand feet more of vertical altitude.

Furthermore, that depth of snow, rather than effective temperature or wind, is the factor of preponderant influence in determining timberline on Mount Rainier is indicated by the fact that on the ridges, which receive the full force of the wind, and some of which are undoubtedly colder than the draws between, the trees go considerably higher than they do in the draws.

The boundaries of all the life zones tend to be lower on Mount Rainier

than on the east slopes of the Cascades. This may be because the sum total of heat units necessary for floral growth and development is less at a given altitude on the west than on the east side. It is unlikely that depth of snow would be of any great importance in determining zonal boundaries below timberline.

In a less humid environment than that of Mount Rainier, as on the east slopes of the Cascades, in the Sierra Nevada or the Rocky Mountains, there would ordinarily be a difference of at least 500 feet (sometimes much more) in the altitude of timberline on north and south slopes. On Mount Rainier this difference is so small that in many localities it is scarcely appreciable.⁴ The effects of humidity through the Rainier region seem to so dominate that the effects of temperature, which would otherwise be clearly registered on north and south slopes, are minimized.

Distributional Problems

COMPOSITION OF BIRD AND MAMMAL COMMUNITIES AND DIRECTION OF INGRESSION

The direction of ingression of 33 species of mammals out of the 55⁵ found in the Park, and of 30 birds out of 102, can be tentatively stated.

Taking the mammals first, 18 species quite certainly entered Mount Rainier from the east and 15 from the west. Lists of these species follow.⁶

FROM THE COASTAL STRIP WEST OF MOUNT RAINIER

Scapanus townsendii
Scapanus orarius
Neurotrichus gibbsii gibbsii
Neosorex bendirii bendirii
Sorex obscurus setosus
Sorex trowbridgii
Spilogale phenax olympica
Mustela streatoria
Microtus oregoni

FROM THE CASCADE MOUNTAINS EAST OF MOUNT RAINIER

Neosorex navigator navigator
Canis latrans lestes
Vulpes cascadenensis
Lynx canadensis
Gulo luscus
Martes caurina caurina
Martes pennanti pacifica
Microtus richardsoni arvicoloides
Microtus mordax mordax

⁴ South-facing slopes are, however, more regularly and heavily timbered than north-facing, due apparently, to the fact that snow banks on the north-facing slopes last longer than on south-facing slopes; then, too, alternate thawing and freezing on south slopes would make more water available over a longer period than on north slopes.

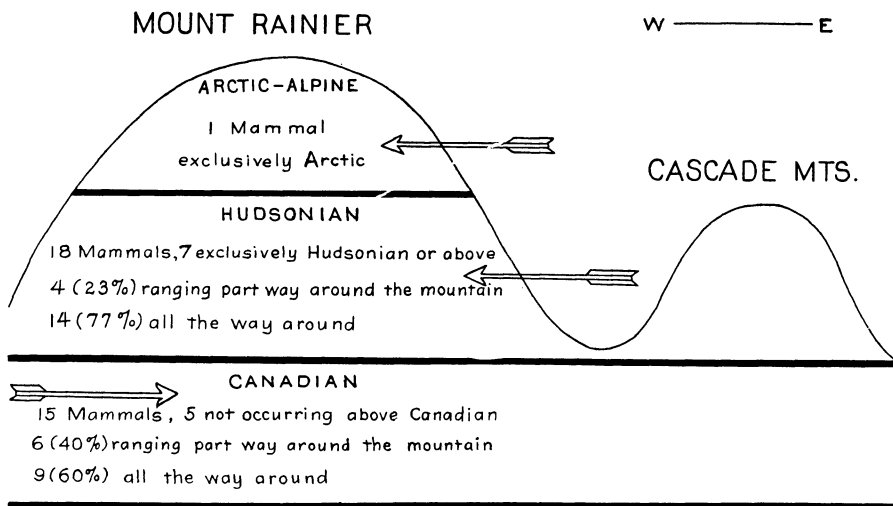
⁵ Some of the species cannot be classified as to direction of ingression, either because they are so wide-ranging that they cannot be said to have entered the Park from any one direction, or because their exact systematic status is uncertain.

⁶ Additional information is likely to modify these lists, which, in the present state of knowledge, must be regarded as tentative. The data presented do, however, suffice, in the writer's opinion, to justify the general conclusions set forth.

Zapus trinotatus trinotatus
Aplodontia rufa rainieri
Eutamias townsendi cooperi
Sciurus douglasii douglasii
Lepus washingtonii washingtonii
Odocoileus columbianus columbianus

Evotomys gapperi saturatus
Phenacomys orophilus olympicus
Thomomys douglasii shawi
Callospermophilus lateralis saturatus
Glaucomys sabrinus fuliginosus
Eutamias amoenus caurinus
Ochotona fenisex bruntescens
Marmota caligata cascadenis
Oreamnos montanus montanus

Mammals ingressing from the west are all derived from or referable to the Canadian or Humid Transition zones of the Vancouver Strip of Piper (1906, p. 40). All occur in the Canadian Zone on Mount Rainier, and all but 5 (*Neurotrichus gibbsii gibbsii*, *Neosorex bendirii bendirii*, *Sorex trowbridgii*, *Spilogale phenax olympica*, and *Lepus washingtonii washingtonii*) have penetrated the Hudsonian Zone. Mammals ingressing from the east are principally derived from the Hudsonian Zone of the high Cascade Mountains. All are known to occur in the Hudsonian Zone on Mount Rainier, and 7 are not known to occur below the Hudsonian Zone. These are *Vulpes cascadenis*, *Gulo luscus*, *Phenacomys orophilus olympicus*, *Thomomys douglasii shawi*, *Eutamias amoenus caurinus*, *Marmota caligata cascadenis*, and *Oreamnos montanus montanus*.



DERIVATION OF MAMMALS ON MOUNT RAINIER

FIG. 2. Diagrammatic cross section of Mount Rainier and the Cascade Mts. from east to west, showing the direction from which the mammals in each zone have come. (Arrows indicate direction of invasion.)

Treating the birds similarly we find that of the species which may be classified in respect to direction of ingression 12 come from the coastal strip to the west, and 18 from the Cascade Mountains to the east. The lists follow:

FROM THE COASTAL STRIP WEST OF
MOUNT RAINIER

Ardea herodias fannini
Lophortyx californica californica
Bonasa umbellus sabini
Empidonax difficilis
Cyanocitta stelleri stelleri
Melospiza melodia morphna
Thryomanes bewicki calophonus
Nannus hiemalis pacificus
Penthestes rufescens rufescens
Regulus satrapa olivaceus
Hylocichla ustulata ustulata
Ixoreus naevius naevius

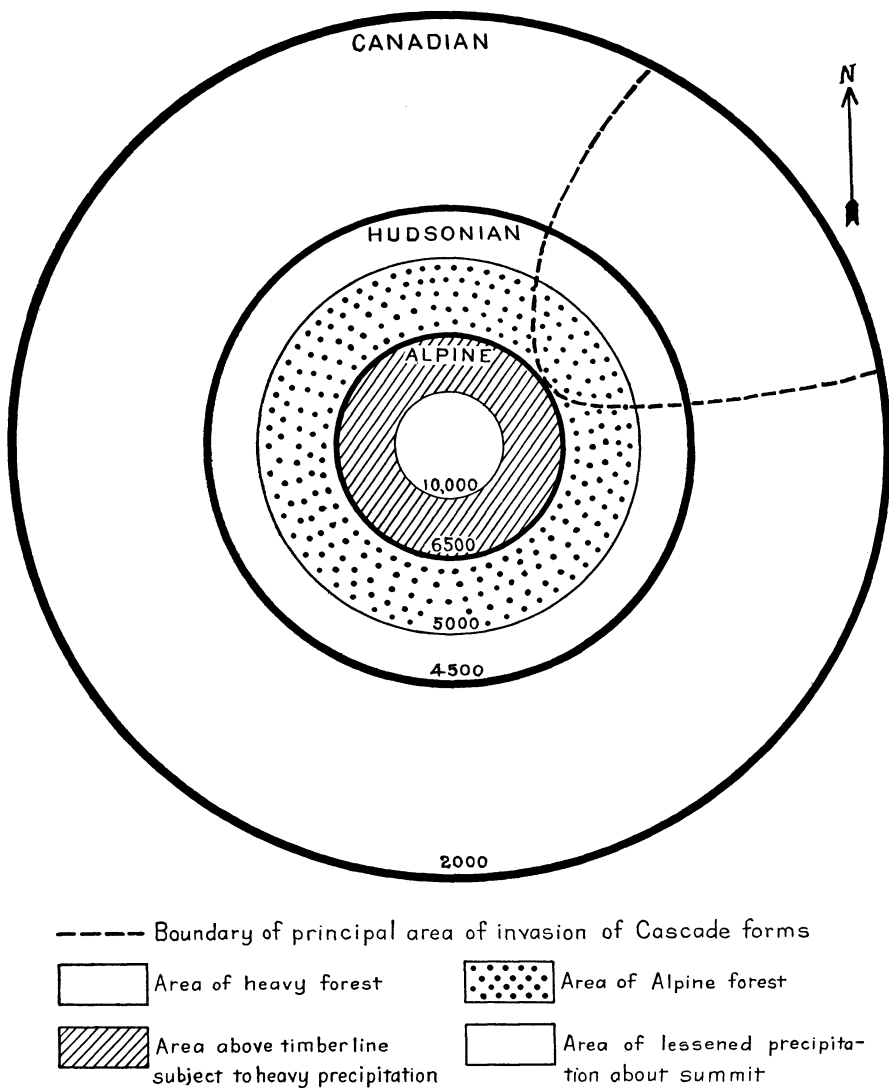
FROM THE CASCADE MOUNTAINS
EAST OF MOUNT RAINIER

Dendragapus obscurus fuliginosus
Lagopus leucurus rainierensis
Pica pica hudsonia
Stellula calliope
Dryobates villosus orius (?)
Nucifraga columbiana
Carpodacus cassini
Loxia leucoptera
Leucosticte tephrocotis littoralis
Spizella passerina arizonae
Melospiza lincolni lincolni
Passerella iliaca schistacea
Anthus rubescens
Sitta canadensis
Penthestes gambeli gambeli
Myadestes townsendi
Hylocichla guttata sequoiensis
Sialia currucoides

Of the 12 birds which have come in from the west, 6 are confined to the Canadian or a lower zone. These are *Ardea herodias fannini*, *Lophortyx californica californica*, *Bonasa umbellus sabini*, *Empidonax difficilis*, *Thryomanes bewicki calophonus*, *Hylocichla ustulata ustulata*. The others range into the Hudsonian Zone to the limit of trees, though several appear to find optimum conditions in the Canadian Zone. No Alpine-Arctic or purely Hudsonian species appear to have ingressed from the west.

Each of the 18 species derived from the Cascade Mountains to the east, except three which are principally Arctic-Alpine (*Lagopus leucurus rainierensis*, *Leucosticte tephrocotis littoralis*, and *Anthus rubescens*), occurs commonly in the Hudsonian Zone. One of the species, *Sitta canadensis*, has apparently found the most favorable conditions in the Canadian Zone. Most of the others find optimum conditions in the Hudsonian Zone. Of the birds ingressing from the east there are 4 which are seldom or never found below the Hudsonian Zone, including the three Arctic-Alpine forms just mentioned, and *Nucifraga columbiana* in addition.

It thus appears that the classifiable species characteristic of the Hudsonian Zone have come from the Hudsonian of the Cascade Mountains to the east, while the classifiable species characteristic of the lower zones have come from the west. It is well known that in general the invisible barriers to geographical distribution, as temperature and humidity, are often more potent than topographic barriers. These invisible barriers certainly have had much to do



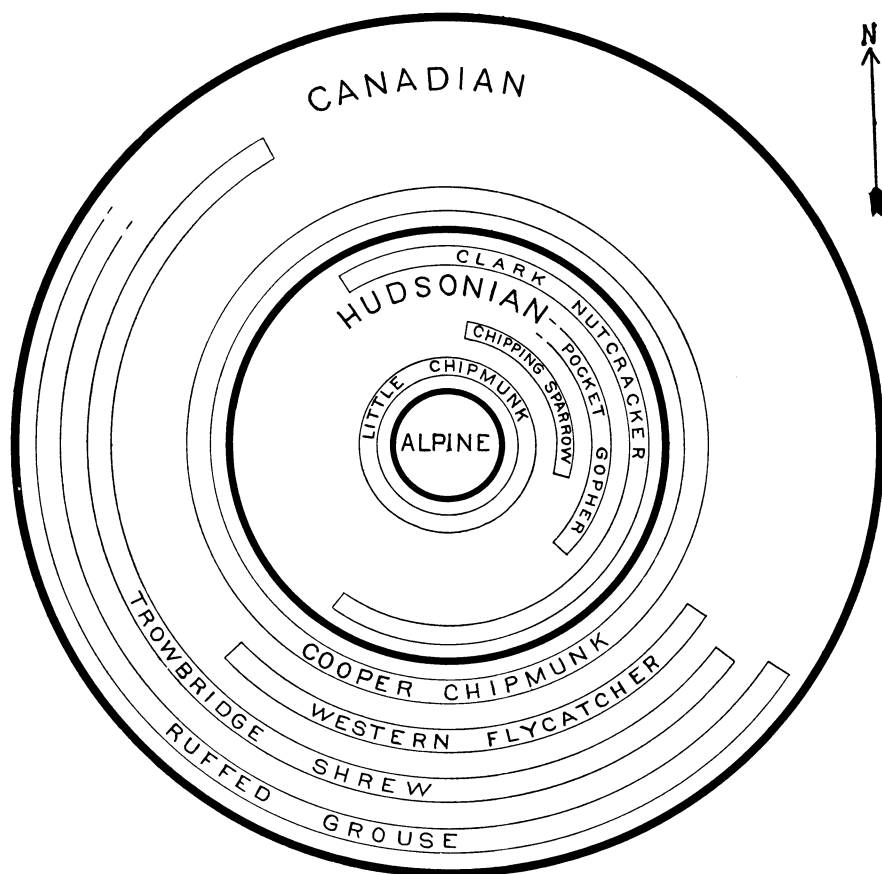
LIFE ZONES OF MOUNT RAINIER (DIAGRAMMATIC)

FIG. 3. Life zones and timber belts of Mount Rainier, showing the area of principal invasion of birds and mammals from the Cascade Mountains.

with the distribution of the birds and mammals of Mount Rainier. Incidentally the usefulness of the life zone concept in elucidating the composition of communities is demonstrated, even in a region where the effects of humidity are pervasive and almost preponderant.

DISTRIBUTION ABOUT THE MOUNTAIN OF BIRDS AND MAMMALS FROM EAST AND WEST

The distribution of the species within a given zone is not uniform about the mountain. For example, of the 15 mammals ingressing from the west, there appear to be only 9 which are to be found all the way around the mountain.⁷ The other species, 6 in number, are found on the west side, but



DISTRIBUTIONAL PROBLEMS ON MT RAINIER

FIG. 4. Diagrammatic representation of the distribution of certain birds and mammals around Mount Rainier.

⁷ The ranges of some of the others might, of course, be extended by further investigation.

range to different distances about the mountain to the east. The latter include *Scapanus townsendi*, *Neurotrichus gibbsii gibbsii*, *Sorex trowbridgii*, *Neosorex bendirii bendirii*, *Spilogale phenax olympica*, and *Lepus washingtonii washingtonii*. Of the 12 birds which have come from the west, only 7 are found all the way around the mountain, the other 5 (*Ardea herodias fannini*, *Lophortyx californica californica*, *Bonasa umbellus sabini*, *Empidonax difficilis*, *Thryomanes bewicki calophonus*) ranging only part way around.

Of the 18 mammals which have ingressed from the Cascades, all but 4 (*Neosorex navigator navigator*, *Microtus mordax mordax*, *Thomomys douglasii shawi*, *Callospermophilus lateralis saturatus*) have found their way entirely around the mountain. Of the 18 birds which have come in from the Cascades, all but 3 have found their way all about the mountain, the 3 being *Nucifraga columbiana*, *Spizella passerina arizonae*, *Penthestes gambeli gambeli*.

Of the birds and mammals from the west, 16 are found all around the mountain and 11 part way; of those from the east, 29 are found all around the mountain and 7 part way. It seems obvious that it has been possible more often for species ingressing from the east to extend their geographic range about the mountain than for those derived from the west. This is probably because the Hudsonian Zone environment, including climate, vegetation, and topography, is more uniform than the Canadian Zone environment. The actual distance around the mountain is greater in the Canadian Zone, but the distances are short at the longest, and it seems unlikely that the comparative distribution of the species concerned offers any valid suggestion as to the relative times of ingression or the relative rates of range extension.

Data regarding ingression of mammals and birds and their distribution about the mountain may be summarized as follows:

Mammals

Species ingressing from the Cascade Mountains east of Mount Rainier	18	
(All occur in the Hudsonian Zone and 7 do not occur below it)		
Species ingressing from the coast strip, west of Mount Rainier	15	
(All occur in the Canadian Zone and 5 do not occur above it)		
Species ingressing from the east, found all the way around the mountain ..	14	77% +
Species ingressing from the east, found part way only around the mountain	4	22% +
Species ingressing from the west, found all the way around the mountain ..	9	60%
Species ingressing from the west, found part way around the mountain	6	40%

Birds

Species ingressing from the Cascade Mountains east of Mount Rainier	18	
(All occur in the Hudsonian Zone and 4 do not occur below it)		
Species ingressing from the Coast Strip west of Mount Rainier	12	
(All occur in the Canadian Zone and 6 do not occur above it)		

Species ingressing from the east, found all the way around the mountain ...	15	83% +
Species ingressing from the west, found part way only around the mountain	3	16% +
Species ingressing from the west, found all the way around the mountain ..	7	58% +
Species ingressing from the west, found part way only around the mountain	5	41% +

Derivation of Zonal Assemblages

1. All classifiable species of both birds and mammals characteristic of the Arctic-Alpine Zone are derived from the Cascade Mountains to the east.
2. All classifiable species, both birds and mammals, characteristic of the Hudsonian Zone are derived from the Cascade Mountains.
3. All classifiable species, both birds and mammals, characteristic of the Canadian Zone are derived from the Coast strip.
4. All classifiable species, both birds and mammals, characteristic of the Transition Zone are derived from the Coast strip.

Summary

1. Mount Rainier is a massive eminence, chiefly basaltic in character, with a warm humid climate and an extremely heavy snowfall. The climatic conditions result in the formation of numerous glaciers. Differences in precipitation on the different sides of the mountain exercise an important influence on the distribution of its birds, mammals, and plants.

2. The *life zone*, mapped on broad lines with *temperature* as the basic factor, and the *habitat* with its *association*, determined chiefly on *water relations*, are relied on to show the distribution of plant and animal life on the mountain.

3. Four life zones are represented, the Transition, Canadian, Hudsonian, and Arctic-Alpine. In general, the Transition Zone includes areas in the southeastern part of the Park below 3,000 feet; the Canadian, the heavily timbered area between 2,000 and 4,500–5,000 feet; the Hudsonian, the sub-alpine meadow country between 4,500–5,000 and 6,500 feet; the Arctic-Alpine, the region above timberline, 6,500 feet and over.

4. The habitats are roughly divisible into three groups: those characterized by extreme moisture, including stream, stream-border, lake, lake-shore, and swamp; those characterized by moderate moisture, including meadow, forest, and burn; and those characterized by deficient moisture or of a rocky type, including alpine ridge, pumice slope, rock-slide, and, tentatively, glacier.

5. The White River region, in the northeastern portion of the Park, possesses several peculiarities: the upper boundary of the Canadian Zone is 500 feet higher in this region than elsewhere in the Park; the White River area is noticeably drier than other parts of the Park; and there are peculiarities in the fauna and flora of the region. These peculiarities probably arise partly or largely from differences in climate induced by the topography of the Rainier region as related to the prevailing southwest winds.

6. Depth of snow seems to be more important than effective temperatures, winds, or other factors in causing timberline on Mount Rainier. The usual effects of temperature in determining the altitude of timberline on north and south slopes are minimized, apparently through the pervasive effects of humidity about the mountain.

7. It has been possible to classify tentatively 63 species of mammals and birds (33 mammals, 30 birds) as to direction of ingress; in general, the mammals and birds of the higher levels on the mountain are derived from the Cascade Mountains east of Mount Rainier, while those of lower levels are derived from the coast strip to the west. Species ingressing from the east have been more successful in extending their ranges about the mountain than those from the west, probably because of the more uniform environment in the higher zones.

The writer is indebted to J. B. Flett, of the National Park Service, Longmire, Mount Rainier National Park, Washington, for generous aid in compiling plant lists and in furnishing photographs; to C. V. Piper, of the Bureau of Plant Industry, Washington, D. C., for correcting plant names used; to Mrs. Jane S. Elliott, of the Bureau of Biological Survey, Washington, D. C., for line drawings utilized; and to E. A. Goldman, E. A. Preble, Hartley H. T. Jackson, and George G. Cantwell, of the Bureau of Biological Survey, for valued advice and helpful suggestions.

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